

EXHIBIT 9



Environmental Health and Medicine Education

[Home](#)

Lead Toxicity

What Are Routes of Exposure to Lead?

Learning Objectives

Upon completion of this section, you will be able to

- Identify the most common routes of exposure to lead in the United States today.

Introduction

Today almost everyone is exposed to environmental lead. Exposure to lead and lead chemicals can occur through inhalation, ingestion, dermal absorption, absorption from retained or embedded leaded foreign body, and trans-placental (endogenous) routes.

- Most human exposure to lead occurs through ingestion or inhalation.
- In the United States, the public is not as likely to encounter lead that readily enters the human body through the skin (dermal exposure), especially now that leaded gasoline is banned for on-road vehicles.
- Retained shrapnel, bullets or other embedded leaded foreign bodies can be a source of ongoing lead exposure.
- Inhalation may be the major contributor for workers in lead-related occupations and “do-it-yourself” home renovators and persons with hobbies (stained glass making/soldering, etc.).

Lead exposure is a global issue. Lead mining and lead smelting are common in many countries, where children and adults can receive substantial lead exposure from often unregulated sources at high levels that are uncommon today in the United States [Kaul et al. 1999; Litvak et al. 1999; Wasserman et al. 1997; López-Carrillo et al. 1996; Rothenberg et al. 1994]. Most countries have discontinued or are in the process of phasing out the use of leaded gasoline for all uses [UNEP 2011].

Ingestion

Lead exposure in the general population (including children) occurs primarily through ingestion, making it the route that most commonly leads to elevated BLLs. This includes swallowing a foreign body containing lead (i.e., jewelry, etc.).

From 20% to 70% of ingested lead is absorbed into the body, (with children generally absorbing a higher percentage than adults) [ATSDR 2010] (see the [“What are Possible Health Effects from Lead Exposure?”](#) section).

- Lead paint is the major source of higher lead level exposures in children in the United States [ATSDR 2010, AAP 1993]. As higher lead content paint
 - Deteriorates,
 - Peels,
 - Chips,
 - Is removed (e.g., during renovation),

- Or crumbles due to friction (e.g., in windowsills, steps, and doors), house dust and surrounding soil may become contaminated. Lead then enters the body through normal hand-to-mouth activity [Sayre et al. 1974, as cited in AAP 1993].
- Ingestion of contaminated
 - Food,
 - Water, or
 - Alcohol may be significant for some populations. In addition, ingesting certain traditional, folk or home remedy medicines may expose people to lead or lead compounds (see the *"Where is Lead Found?"* section).
- When fine particulate lead is inhaled, it can be absorbed directly through the lungs or could also be carried by the mucociliary tree to the throat where it can be swallowed and absorbed via the GI system.

Inhalation

Inhalation is the second major pathway of exposure for the general population in the United States. The amount absorbed from the respiratory system depends on particle size, respiratory volume, amount of deposition, and the mucociliary clearance of the inhaled lead.

- Almost all inhaled lead is absorbed into the body (with children generally absorbing a higher percentage than adults, as they have a higher respiratory frequency) [ATSDR 2010] (see the *"What are Possible Health Effects from Lead Exposure?"* section).
- Since leaded gasoline additives were phased out beginning in the 1970s and control measures were implemented in industries to reduce air emissions, inhalation from these sources is no longer the major exposure pathway to lead for the general population in the United States.
- Leaded gasoline is still used in only a handful of countries, but the resulting emissions pose a major public health threat.
- Inhalation may be the primary route of exposure for some workers in industries that involve lead.
- Inhalation may be the primary route of exposure for adults involved in home renovation activities, and hobbies like lead glass making, stained glass making/soldering.
- Lead is a component of tobacco and tobacco smoke, and smokers have higher blood lead levels (BLLs) than do nonsmokers [Mannino et al. 2005; Mannino et al. 2003].
- Second hand smoke may contribute to increased BLLs in U.S. children. Lead dust concentrations, usually ingested during hand to mouth activity, do not appear to mediate this association, suggesting inhalation of second hand smoke is a major pathway of exposure [Apostolou et al. 2012].
- Eliminating second hand smoke exposure may reduce lead exposure in children [Apostolou et al. 2012].

Dermal

Dermal exposure plays a role for exposure to organic lead among workers, but is not considered a significant pathway for the general population.

- Organic lead may be absorbed directly through the skin.
- Organic lead (tetraethyl lead) is more likely to be absorbed through the skin than inorganic lead.
- Dermal exposure is most likely among people who work with lead or materials that contain lead.

Endogenous Exposure

Endogenous exposure to lead may contribute significantly to an individual's current BLL. Numerous reports document lead poisoning resulting from retained bullet or shrapnel fragments; thus, a history of military or other penetrating trauma may be important [Kathuria 2014]. If in a pregnant woman, this poses a particular risk to the developing fetus (See the *"What are Possible Health Effects from Lead Exposure?"* section). Trans-placental exposure to the unborn child can happen if the mother is exposed to lead.

- Once absorbed into the body, lead may be stored for long periods in mineralizing tissue (e.g., teeth and bones).
- The stored lead may be released again into the bloodstream, especially in times of calcium stress (e.g., pregnancy, lactation, osteoporosis) or calcium deficiency.

Key Points

- Ingestion is the most common route of exposure to lead for children, and the route that most commonly leads to elevated BLLs.
- Inhalation can be a significant exposure pathway, particularly for workers in lead industries, “do-it yourself” home renovators, persons with hobbies (stained glass making/soldering), smokers and children exposed to second hand smoke.
- Embedded or retained leaded foreign bodies can be a source of ongoing lead exposure.
- Trans-placental exposure to the unborn child can happen if the mother is exposed to lead.

Progress Check

3. The two primary routes of exposure to lead in U.S. children are

- A. Ingestion and inhalation.
- B. Inhalation and dermal.
- C. Dermal and endogenous.
- D. Endogenous and inhalation.

Try Again

Check My Answers



Embed

Disclaimer

Privacy

Last Reviewed: May 24, 2023